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Title: A SYSTEMS APPROACH TO PROJECT RISK MANAGEMENT

Author(s): John P. Kindinger

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John P. Kindinger

Probabilistic Risk Analysis Group
Decision Applications Division
Los Alamos National Laboratory
Los Alamos, NM 87545, USA

ABSTRACT

This paper describes the need for better performance in the planning and execution of projects and examines the capabilities of two different project risk analysis methods for improving project performance. A quantitative approach based on concepts and tools adopted from the disciplines of systems analysis, probabilistic risk analysis, and other fields is advocated for managing risk in large and complex research & development projects. This paper also provides an overview of how this system analysis approach for project risk management is being used at Los Alamos National Laboratory along with examples of quantitative risk analysis results and their application to improve project performance.

KEYWORDS

Project, risk, analysis, quantitative, systems

THE NEED FOR PROJECT RISK ANALYSIS

Most readers attracted by the abstract of this paper will have at least an intuitive concern that projects they are involved with could fail in some significant fashion and consequently affect the financial well-being of their employer and/or themselves. Others, like me, may have experienced such an event first hand. But how common are the occurrences of project failure?

Exhibit 1 displays some insightful research data on the actual record of project failure in several industries. Note that in all industries an overwhelming majority of all projects fail in at least achieving some important objective. These Category 2 failures include significant schedule and/or budget overruns. Beyond this, the occurrence of total project failure is alarmingly high. In addition, at least one source (1) indicates that project performance may not be improving with time. Thus, there seems to be a prima facie case for the need to improve project performance and I believe that project risk analysis can be an important means for achieving better performance.

EXHIBIT 1 – RESEARCH RESULTS ON PROJECT FAILURE LIKELIHOOD

Project Outcome Categories	Likelihood (%)			
	Nuclear Power after TMI (3)	Information Technologies (7)	Process Industries (1)	Your Business?
1 Success	0%	26%	33%	
2 Completed but one or more major objectives not met	60%	46%	67%	
3 Total failure / not completed	40%	28%	N/A	

THE CASE FOR QUANTITATIVE PROJECT RISK ANALYSIS

The use of risk analysis techniques to aid in project management has increased significantly in recent years, but is still in an early stage of technological development. This is especially true in the area of quantitative or systems based project risk analysis. By "systems based" I mean an analysis approach derived from the discipline of systems analysis or system dynamics. In the systems approach, a mathematical model is used to predict project performance, including uncertainty, and risk is defined as a condition that has the potential to produce negative or unwanted performance. This method stands in contrast to the qualitative "risk matrix" approach that seeks to list potential risk issues and rank them into categories defined by subjective frequency and consequence assignments.

Current guidance documents such as the PMI *PMBOK* (6) and the *Risk Management Guide for DoD Acquisition* (8) generally address a spectrum of possible methods and tools that can be used in performing project risk analysis, but do not adequately describe what should be expected from a project risk analysis or present a complete and coherent approach for performing quantitative project risk analysis.

Expectations for Risk Analysis

The following list provides what I believe are the basic outputs and functional capabilities that a manager should expect from a project risk analysis. The exhibit also indicates how well the two analysis methods I have discussed meet these expectations.

EXHIBIT 2 – EXPECTATIONS FOR PROJECT RISK ANALYSIS

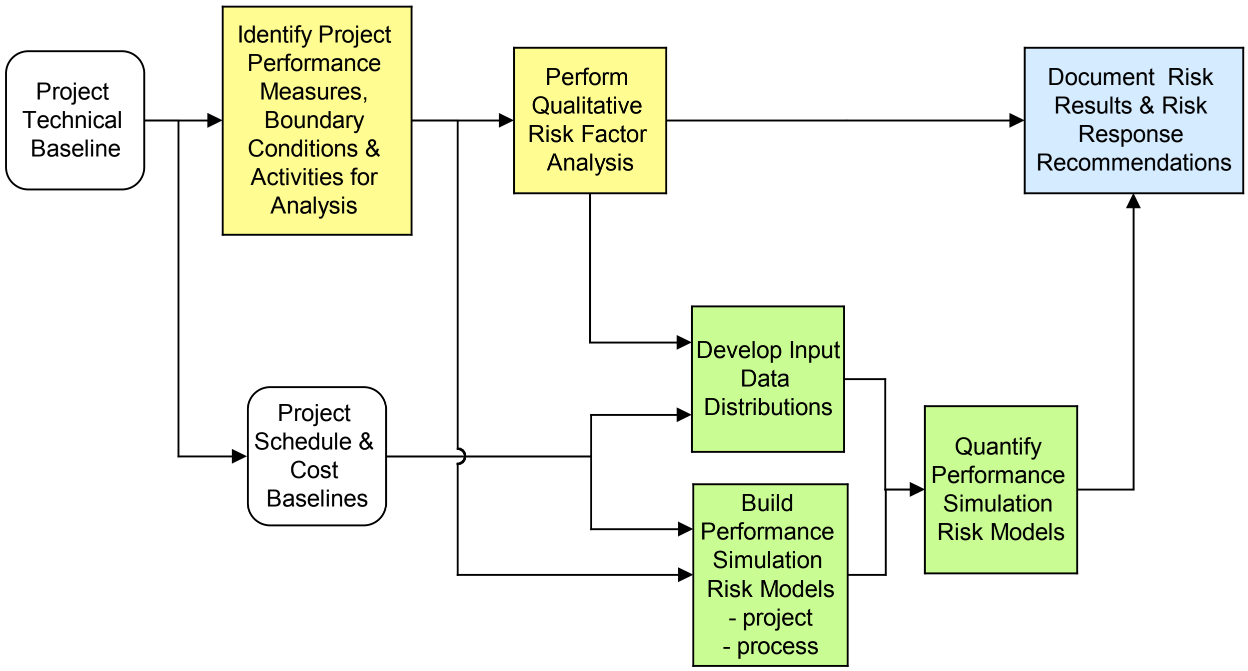
Expectations for Project Risk Analysis	**Expectations Met by:**	
	Risk Matrix Approach	**Systems Approach**
Outputs		
1) Quantitative results, including uncertainty, for tasks and the total project	**No**	**Yes**
2) Identification of the important contributors to uncertainty by task and total project	**No**	**Yes**
3) Identification of potential risk reduction actions	**Partially**	**Yes**
4) Identification of key boundary conditions	**Yes**	**Yes**
5) Satisfaction of project risk management requirements	**Yes**	**Yes**
Analysis Features and Capabilities		
1) A systematic and consistent methodology	**Partially**	**Yes**
2) Quantitative bases for establishing project cost and schedule targets and contingencies	**No**	**Yes**
3) Costs/benefits assessments for potential risk reduction actions ("What if" cases)	**Partially**	**Yes**
4) Results that include project wide“ripple” effects	**No**	**Yes**
5) Corrections for common errors inherent in deterministic scheduling and cost estimating methods	**No**	**Yes**
6) Ability to upgrade results with actual data	**Partially**	**Yes**

Clearly, quantitative, systems based project risk analysis offers significant advantages in performance. Now, I will discuss the analysis tasks that are required to realize these benefits.

PERFORMING QUANTITATIVE PROJECT RISK ANALYSIS

The key activities involved in performing a quantitative, systems based project risk analysis are shown in Exhibit 2. As seen in the Exhibit, the risk assessment consists of both qualitative analysis tasks, quantitative analysis tasks and documentation tasks that bridge both areas. In the space available for this paper, only brief explanations of these tasks are possible. References (2, 4 and 5) offer additional information and interested readers are encouraged to contact the author with more specific questions.

EXHIBIT 3 – PROJECT RISK ANALYSIS TASK FLOWCHART



The project risk analysis process begins with the selection of appropriate performance measures and quantifiable goals or milestones. Activity identification is based on process or project task definitions already in use. Typically at LANL, flowcharts are developed to document the tasks to be modeled and their interrelationships. The flow charts are developed in sufficient detail to allow important risk contributors to be identified and evaluated individually yet be simple enough for all key tasks and their interrelationships to be viewed in a manageable fashon. Boundary Conditions define the programmatic/bureaucratic/economic environment that support the successful conduct of the project. This environment is often determined by events outside the control of the project team. However, experience with long-term projects demonstrates that significant changes in boundary conditions are not only possible but likely to occur. Even though outside the control of the project team, it is prudent to identify critical enabling boundary conditions as part of the risk assessment so that issues included and not included in the analysis are understood by all participants and possible strategies for minimizing risks from changing boundary conditions can be identified.

Risk Factor Analysis (RFA) is a comprehensive and systematic qualitative risk assessment process aimed at identifying the underlying technical, schedule, cost and funding risk factors that ultimately will drive the behavior of the top-level schedule, cost, and technical performance measures for a project. The RFA process requires interviews and other interactions with a complete spectrum of project personnel. Details of the RFA can be found in Reference 4.

The simulation risk models built to date at LANL vary considerably in size and complexity and have been developed using a variety of modeling tools. The models generally fall in two categories with the first being linear task sequence or network models and the second being recurring batch or continuous product manufacturing models. Both often exist within a single project model and exchange data about important constraints and milestones.

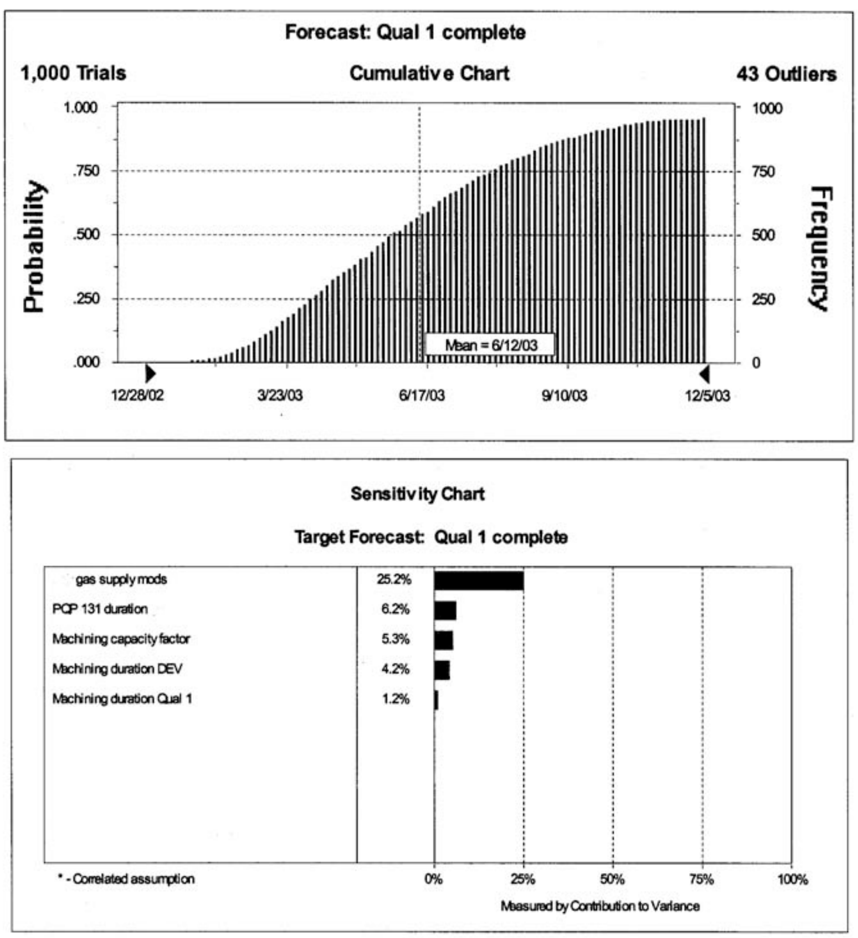
Input data distributions for the simulation risk models are developed from baseline deterministic data used in typical planning, scheduling and cost estimating sources combined with the findings of the Risk Factor Analysis. General guidelines are used to assign uncertainty to the deterministic point estimate data based on the results of the RFA, however, considerable judgement and data analysis experience are still required in this process.

Risk model results are produced by inserting the input data distributions into the models and running the simulation. Before this however, the model is benchmarked by exercising it with project baseline point estimate data to confirm that the risk model produces the predicted baseline results, before the addition of uncertainty into the calculation.

EXAMPLE RESULTS

The output of the risk simulation model includes cumulative probability distribution functions (PDF) describing the confidence level ascribed to the achievement of different results for selected project performance measures. An example PDF for completion of a critical product from a LANL project is shown in Exhibit 4.

EXHIBIT 4 – EXAMPLE QUANTITATIVE RISK ANALYSIS RESULT



Percentile	Value
0%	12/22/02
5%	2/24/03
10%	3/11/03
15%	3/21/03
20%	3/31/03
25%	4/9/03
30%	4/19/03
baseline	4/24/03
35%	4/28/03
40%	5/9/03
45%	5/19/03
mean	5/26/03
50%	5/29/03
55%	6/9/03
60%	6/21/03
milestone	3qtr'03
65%	7/1/03
70%	7/15/03
75%	7/30/03
80%	8/14/03
85%	8/31/03
90%	9/25/03
95%	11/16/03
100%	2/7/04

The simulation model output also includes rankings of the sensitivity of the performance measure results to the individual inputs, thus identifying the most important contributors to risk for potential mitigation actions.

Using the sensitivity results and findings from the qualitative Risk Factor Analysis, potential actions available to eliminate or mitigate the identified risks can be identified, evaluated for effectiveness and adopted for implementation. The results of this process are documented in a risk watch list.

Quantitative project risk analysis results like those shown in Exhibit 4 can also be used to provide a rational bases for setting baseline schedule and cost targets and establishing appropriate contingencies for the project.

CONCLUSION

This paper has established the need for improved project performance and specified the analysis capabilities and outputs that systems based quantitative project risk can provide to that purpose. A brief overview of the project risk analysis methods being employed at LANL along with example results were also presented. It is my hope that the information in this paper may increase both the expectations that managers have for the role that risk analysis can play in project planning and management and also increase their confidence in the applicability of quantitative project risk analysis for a broad spectrum of projects and programs.

REFERENCES

1. Howard, RM, (1997), *The Business Stake in Effective Project Systems*, The Business Roundtable.
2. Houghton, FK and Kindinger, JP, (2001), *LANL's Development of Schedule Contingency Based on Probabilistic Risk Results*, Proceedings of the Project Management Institute Annual Seminars & Symposium, Houston, Texas, USA
3. Kindinger, JP, (1985) *Analysis of Lead Times and Causes of Delays in U.S. Nuclear Power Plant Projects since 1980*, Masters Thesis, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.
4. Kindinger, JP and Darby, JL, (2000), *Risk Factor Analysis – A New Qualitative Risk Management Tool*, Proceedings of the Project Management Institute Annual Seminars & Symposium, Houston, Texas, USA
5. Kindinger, JP and Darby, JL, (1999), *Use of Probabilistic Cost and Schedule Analysis Results for Project Budgeting and Contingency Analysis at Los Alamos National Laboratory*, Proceedings of the Project Management Institute Annual Seminars & Symposium, Philadelphia, Pennsylvania, USA
6. Project Management Institute, (2000), *A Guide to the Project Management Body of Knowledge*, Chapter 11, *Project Risk Management*, Project Management Institute.
7. The Standish Group, (1995), Chaos
8. U.S. Department of Defense, (2001) *Risk Management Guide for DoD Acquisition*, Fourth Edition, Defense Systems Management College Press.